Chapter 2
Theoretical Framework: A Spatial Perspective On Innovation and the Genesis of Regional Growth

2.1 Introduction

Technological change seems to be making innovation not only more "globalised" but also more "territorially-specific". Innovation relies on "global" knowledge flows of formal codified knowledge, but as these flows become progressively easier to access and exchange, the territorial aspect of innovation and learning has become a key resource in competitive advantage. In order to understand this process, however, it is necessary to reconsider the linear model of innovation. As we will discuss in this chapter, innovation is a collective learning and socially embedded process that is crucially dependent on tacit knowledge and "untraded interdependencies". Consequently a dialectical linkage has been established between innovation and space. While territories, with their social, cultural and institutional realm, are crucial for successful innovation, innovation is in turn a key source of competitive advantage for territories and regions. However, different streams of literature have shed light upon specific factors and "conditions" involved in the process without bringing them together in an analytical model.

The capacity to innovate and to assimilate innovation have regularly been considered as two of the key factors behind the economic dynamism of any territory (Feldman and Florida 1994; Audretsch and Feldman 1996; Cantwell and Iammarino 1998; Furman et al. 2002). Yet, despite this agreement, researchers have tried to untangle the link between research, innovation, and economic growth in very different ways. Three different approaches to this relationship predominate. The first is the so-called "linear model" (Bush 1945; Maclaurin 1953), whereby basic research leads to applied research and to inventions, that are then transformed into innovations, which, in turn, result in greater growth. Empirically, this type of analysis focuses fundamentally on the link between R&D and patents, in the first instance, followed by that between patents and growth. These types of analysis are fundamentally conducted by "mainstream economists" and, despite criticisms (e.g., Rosenberg 1994), the approach remains popular with academics and policy makers. A second group can be classified under the appellations of "systems of innovation" (Lundvall 1992) or "learning region" (Morgan 1997) approaches. These approaches, associated with evolutionary economics (Dosi et al. 1988;

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Freeman 1994), concentrate on the study of territorially-embedded institutional networks that favour or deter the generation of innovation. The capacity of these networks to act as catalysts for innovation depends, in turn, on the combination of social and structural conditions in every territory, the so-called "social filter" (Rodríguez-Pose 1999). These approaches tend to be fundamentally qualitative and mainly conducted by geographers, evolutionary economists, and some economic sociologists. Finally, there is a large group of scholars who has mainly concentrated on the diffusion and assimilation of innovation (Jaffe 1986; Audretsch and Feldman 1996a; Cantwell and Iammarino 2003; Sonn and Storper 2008). This knowledge spillovers approach has been generally adopted by economists and geographers, using both quantitative and qualitative methods.

Although such a wide variety of approaches contributes significantly to improve our understanding of the process of innovation and of the linkages between innovation and economic development, the theoretical mechanisms developed by these different, but nevertheless, complementary strands of literature have rarely been combined. There has been little cross-fertilisation. Major operational and methodological barriers have hitherto kept any potential interaction to a bare minimum. The main reasons for this lack of interaction are related to the different disciplinary backgrounds of the researchers working on innovation, to the different methods used by different approaches, and to the difficulties in operationalising some of the concepts used by different strands of the literature on the topic.

This chapter represents an attempt to try to bridge this gap in the literature by combining in one model linear, innovation systems, and spillover approaches in order to develop an "integrated framework" for the understanding of regional growth dynamics, setting out the foundations for the analyses to be pursued in the subsequent chapters.

In order to achieve this aim, we ground our approach on a series of fundamental theoretical mechanisms which make knowledge and its transmission an important explanation for differential growth performance. First, as highlighted by the linear model of innovation, local innovative activities are crucial for the "production" of new knowledge and the economic exploitation of existing knowledge, given the presence of a minimum threshold of local innovation capabilities (as put forward by evolutionary economics and neo-Schumpeterian strands). Such activities are not geographically evenly distributed and thus become a localised source of competitive advantage for some areas rather than others. Second, information is not automatically equivalent to economically-useful knowledge (Sonn and Storper 2008). A successful process of innovation depends on "localised structural and institutional factors that shape the innovative capacity of specific geographical contexts" (Iammarino 2005, p. 499), as indicated by the systems of innovation (Lundvall 2001), regional systems of innovation (Cooke et al. 1997) and learning regions (Morgan 2004; Gregersen and Johnson 1996) approaches. And third, technological improvements in "communication infrastructures" have not affected all kinds of information in the same way. While "codified information" can be transmitted over increasingly large distances, "tacit" knowledge is geographically bound thus determining the increasing concentration of innovation and the geographical boundedness of knowledge spillovers (Audretsch and Feldman 2004; Cantwell and Iammarino 2003; Sonn and Storper 2008).

The integration of these streams of literature will allow us not only to assess how differences in innovative activities can explain differential regional economic performance, but also to show how exposure to localised knowledge spillovers together with indigenous socio-economic conditions, may significantly influence a region's capacity to translate such efforts into economic growth.

This chapter is organised into seven further sections. In the first six sections the theoretical relationships are analysed in order to explain the mechanisms driving and conditioning the translation of innovative efforts into growth. Building on such analysis, the final part outlines an empirical model which extends the neoclassical linear growth model and in which each variable is justified and grounded in the previously developed theoretical framework.

2.2 Innovation and Regional Growth

The possibility of explaining regional growth differentials on the basis of differentiated innovative activities relies on the understanding of the mechanisms through which knowledge is created and translated into growth. Where technological progress is seen, as in the traditional neoclassical perspective, as independent of capital accumulation, economies of scale, human capital and, above all, as a truly public good, its creation is unrelated to the rest of the economic system and the understanding of its effect on growth rates is regarded as a "residual" matter, after the traditional factor of production have been accounted for (Solow 1957; Borts and Stein 1964; Richardson 1973 when regions are considered). In such a perspective exogenous and freely available technological knowledge together with the assumption of decreasing returns to capital produce, in the long run, automatic convergence in regional growth rates without any role being assigned to indigenous innovative activities.

When, in contrast to neoclassical assumptions, technology and human capital accumulation are fully recognised as the result of explicit decisions of economic agents, economic growth becomes "an endogenous outcome of an economic system, (and) not the result of forces that impinge from outside" (Romer 1994, p. 3). Technology, technological progress, and human resources – considered as the main forces "behind perpetually rising standards of living" (Grossman and Helpman 1991, p. 24) – become endogenous, and change differently in different territories according to the quality of human resources and to the amount of human and physical capital devoted to research and development (Romer 1986; Lucas 1988; Rebelo 1991). Innovation takes place where the adequate endowments of human and physical capital are located and, vice versa, innovation generates economic dynamism which attracts more human resources and more capital. Hence, under an endogenous growth framework, innovation and human capital will tend to co-locate in relatively compact geographical areas.

When "the underlying source of sustained growth in per-capita income, namely the accumulation of knowledge" is endogeneized "through formal education, on the job training, basic scientific research, learning by doing, process innovations, and product innovations" (Aghion and Howitt 1992, p. 1) the relevance of indigenous innovative activities changes completely. When the "endogenous growth model" fully incorporates the view of innovation as a result of deliberate efforts, a wholly new light is shed on the contribution of innovation towards the understanding of growth dynamics. New knowledge is not a pure public good but is "produced" by existing knowledge and human capital through investment in R&D, remunerated by the temporary extra-rent provided by the (partial and at least temporary) appropriability of the results of innovation (Romer 1990, Grossman and Helpman 1991 in a monopolistic competition framework). However, as the benefits of innovative efforts are not fully appropriated by the innovative firm/nation/region because knowledge "spills over", the existing pool of knowledge is also increased thereby also benefiting other operators in their additional innovative activities.

Thus the inclusion of innovation efforts into the determinants of growth allows this theoretical perspective to account for permanent regional disparities in the rates of growth. Therefore, regions that are well endowed in terms of knowledge and human capital, thanks to their accumulated pool of knowledge, will have a "continuous advantage over less well-endowed regions which rely on exogenously embodied technology (in the shape of new capital equipment purchased from other regions) because they are not capable of producing their own" (Armstrong and Taylor 2000, p. 87).

In this context the ways in which knowledge is transmitted from its "producers" to the whole set of potential (intended or unintended) beneficiaries becomes a crucial issue. Technological knowledge is not exhausted after use. It is cumulative, being based on an existing pool of knowledge, and rarely completely appropriable by whoever holds its property rights. It produces spillovers whose effects offer an additional important explanation of differentiated development patterns. Industry-specific spillovers suggest that the different specialisation pattern of each region may result in different growth performances, while geographically concentrated spillovers (as those analysed in Audretsch and Feldman 1996a) produce a local accumulation of knowledge, which, through a cumulative causation mechanism, facilitates the clustering of economic activity (Maurset and Verspagen 1999).

By bringing innovation to the fore, it is often assumed that greater investment in basic R&D will lead to greater applied research and to an increase in the number of inventions, that, when introduced in the production chain become, growth-enhancing innovations. This linear perception of the innovation process has localised R&D investment has the key factor behind technological progress and, eventually, economic growth. In essence, the implications of this approach are that the higher investment in R&D, the higher innovative capacity, and the higher the economic growth. Despite being much derided (e.g., Fageberg 1988; Verspagen 1991; Rosenberg 1994; Morgan 1997), the linear model remains popular with academics and policy makers because of its simplicity and powerful explanatory capacity: nations and regions that invest more in R&D, generally tend to innovate more, and often grow faster. But by focusing on local R&D, the linear model completely disregards key factors about how innovation is actually generated. These factors are related to the context in which innovation takes place and to the potential for territories to assimilate innovation being produced elsewhere.

The potential for the concentration of economic activity and for divergence becomes more evident when issues such as the minimum thresholds of R&D and of appropriability of technology – highlighted by the neo-Schumpeterian strand of the endogenous growth approach – are considered. For R&D investment to be effective a minimum threshold of investment is necessary, making the relationship between investment in R&D and economic growth not linear. Furthermore there are strong threshold effects and external economies associated with R&D investment and returns from R&D rely heavily on the quality of the workforce conducting research, on the concentration of R&D centres in limited spaces, on the quality of the local human capital (Audretsch and Feldman 1996a; De Bondt 1996; Engelbrecht 1997), and, above all, on the amount of investment (Scherer 1983; Dosi et al. 1988). Hence, limited and/or dispersed investment in R&D in lagging areas may not yield the expected returns, as most R&D projects may lack the adequate dimension to conduct competitive research and local scientists and researchers are likely to be more isolated than in advanced technological centres. In addition, as will be discussed in further detail below, the local economic fabric may lack the capacity to successfully achieve the passage from technological progress to innovation and to economic growth (Rodríguez-Pose 1999).

2.3 A Broader View On the Process of Innovation: The Innovation Systems Approach

As underlined in the previous paragraphs, knowledge and innovation are important sources of regional growth. However, there are other factors which have to be accounted for because, *ceteris paribus*, regions show differential capabilities to absorb and translate available knowledge into (endogenous) economic growth. Many of the agglomeration effects of the endogenous growth theories are reinforced by the predictions of numerous institutional theories that underline the role of institutions and institutional factors on economic activity. These theories, despite their different origins, coincide on the role played by institutions in fostering economic concentration.

Many studies have unearthed a close link between "good" institutional conditions or the presence of strong communities and the clustering of economic activities. Qualitative work on clusters and industrial districts (e.g., Piore and Sabel 1984; Kristensen 1992; Semlinger 1993; Burroni 2001), "learning regions" (Gertler et al. 2000; Henry and Pinch 2000; Bathelt 2001), and regional systems of innovation (Cooke and Morgan 1998) stresses how complex institutional and governance arrangements create the conditions for economic activity to thrive and ultimately – as good institutional conditions are hard to replicate – to agglomerate. Factors such as the close interaction among local political actors, the presence of a functioning civil society, regional administrations, employers organizations and trade unions – in what Trigilia (1992) calls an "institutionalized market" – favour economic development and agglomeration. Well developed traditions, strong trade unions co-operating with employers, and nation-wide institutions work in a similar direction. Conversely, the absence of poles of collective action often leads to the formation of vicious circles of low growth. The lack or relatively little importance in social life of collective organizations, the presence of clientelistic practices, or the governing of social activity by simple social structures (often characteristic of relatively remote and backward spaces) facilitate migration and discourage economic activity.

Many quantitative analyses reach similar results. Putnam's (1993) work on Italian social capital shows how differences in levels of community institutions between Northern and Southern Italy are at the base of their sizeable income inequalities. Other research has found that different institutional proxies of community, such as group participation, help explain higher economic performance (Knack and Keefer 1997; Zak and Knack 1998; Beugelsdijk et al. 2004; Guiso et al. 2004), or that, conversely, excessive divisions within societies limit their growth potential (Easterly and Levine 1997; Rodríguez-Pose and Storper 2006).

Taken to its limits, some analysts indicate how having a high density of closely-knit institutional networks in close physical proximity – called "institutional thickness" by Amin and Thrift (1995) and "institutional capital" by Healey (1998) – is a key condition for economic development. Combinations of "intellectual capital" (i.e., knowledge resources), "social capital" (trust, reciprocity, cooperative spirit and other social relations), and "political capital" (capacity of collective action) within these institutional networks determine the potential for development. The greater the density of complex institutional networks within a given territory, the greater the potential for higher growth and development (Amin and Thomas 1996; Morgan 1997; Cooke and Morgan 1998).

How can this heterogeneous body of literature be reconciled with the theories of innovation and growth discussed in the previous paragraph? The empirical evidence shows that "the ability to adapt new technologies depends on the institutional infrastructure, education, geography and resources devoted to R&D" (Maurseth and Verspagen 1999, p.152). These factors can be included in the analysis of the process of innovation following different, but reconcilable (as we will see), theoretical approaches to such a process.

According to the formal neoclassical perspective of the "technology gap theory" (Abramovitz 1985; Fagerberg 1988; Verspagen 1991) differentiated "absorptive" capabilities – in their turn the result of different economic and institutional infrastructures – determine the clustering and geographical concentration of economic activity. Instead, moving towards an "institutionalist" perspective, where innovation is not directly the outcome of a linear production function, the institutional environment acts directly as the generator of creative synergies and externalities (Dosi et al. 1988; Freeman and Soete 1997 among the others). The "evolutionary approach" (e.g., Nelson and Winter 1982), on the other hand, focuses upon the process of transformation of new ideas (genotypes) into technological advances through a series of mutations whose "evolutionary success" is determined by a natural market selection.

All these heterogeneous (but only up to a certain extent[1]) views fit into the common conceptual framework of "systems of innovation": "the network of institutions in the public and private sector whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman 1987, p. 1).

Lundvall (1992) broadens this systemic view to include all the parts of the economy and its institutional infrastructure that affect the learning process and suggests that historical and theoretical aspects be jointly considered in order to discriminate what (and what not) to include in the analysis of the individual case under scrutiny. Thus, in this perspective, the definition of innovation not only includes the creation of the Schumpeterian "New combinations", but also their "diffusion" (as in Nelson) and "new forms of organisation" and "institutional innovation".

The operational translation of the concept of systems into a concrete spatial (national or regional) or sectoral dimension[2] gives rise to the concepts of sectoral, national and regional systems of innovation. In what follows we will focus upon the geographical approach, even if the strong complementarities between the sectoral and the geographical approach (Edquist 1997), will allow them to be considered in a common framework.

2.4 The Regional Perspective: Regional Systems of Innovation and the "Social Filter"

Within each national system of innovation a marked degree of unevenness in the geographical pattern of innovative activities has to be registered. This phenomenon does not only depend on the degree of centralization of the individual national territories as "even countries with fairly uniform rates of innovation geographically can hide quite marked disparities on a local or regional level (in terms of systems of innovation)" (Howells 1999, p. 69). The analysis of such disparities leads to the hypothesis of the existence of "self-consistent" regional systems within the

[1]Evolutionary and interactive learning approaches can be easily reconciled when, following Edquist (1997), interactive learning is considered as a selection mechanism in an evolutionary process.

[2]In this area there is no agreement in the literature about the most convincing approach. Some authors (Nelson and Rosemberg, 1993 and Lundvall 1993) even question the rationale for the study of national systems of innovation preferring the idea of the emergence of a truly global system.

framework of national ones. In a "top–down" perspective, as pointed out by Howells (1999), the regional system fundamentally originates from "discontinuities" and regional unevenness in the national components of the system (governance structure and institutional arrangements, regional industry specialisation, educational policies etc.) or by the different ways in which both national institutions and regulatory frameworks actually work at a local level. On the contrary, when, in a bottom-up perspective, the role of face-to-face contacts and tacit knowledge is considered local and regional systems are no longer proto-systems at the lower level of a hierarchical scale (from global to local) but key building-blocks and the engine of the innovative process. In this perspective the process of innovation is not separate from the entire functioning of the socio-economic sphere but embedded in the (various) territorialized processes responsible for the economic performance of each economic space. Innovation thus needs to be linked to the cluster structure of the economy and the regional innovation system should be understood in terms of the relationships and flows between the various actors and parts of the innovation system itself (Cooke 1997). In this sense the regional innovation systems approach shows important points of contact with the most advanced theories of regional development. The concepts of socio-cultural milieu, heterarchies and networks (as opposed to hierarchical relationships), tacit knowledge and embedded interfirm organizations are part and parcel of a common language (Cooke 1998) which can be referred to as the "network" or "associational" paradigm (Morgan 1997). These perspectives are brought into a systematic theoretical view in the Storper's (1997) "holy trinity of the reflexive turn" of regional development (technologies, organizations and territories). "The regional development problem associated with building different systems of innovations thus turns essentially on building the capacities for reflexive, collective action and the forms of coordination consistent with the kind of action required in each world (of production)[3]" (Storper 1997, p. 126). Each "basic kind of product" is thus associated with a different system of innovation thereby accounting for the "fundamental diversity" of the world economy. This theoretical framework, which would be over-ambitious to try to analyse here, not only harmonically "embeds" innovation into its socio-economic context but also effectively integrates sectoral and territorial systems of innovation.

Some of the most relevant findings related to these approaches are the relevance of proximity, local synergy, and interaction (Camagni 1995a; Camagni and Capello 2003) and the importance of "inter-organization networks, financial and legal institutions, technical agencies and research infrastructures, education and training systems, governance structures, innovation policies" (Iammarino 2005, p. 499) in shaping innovation. The explanatory capacity of such approaches is, however, somewhat constrained by the problems of operationalising in a relatively homogenous way across territories the territorially-embedded networks, social economic structures, and institutions that are at the heart of these approaches. By nature the systemic

[3]"Each (. . .) set of conventions describes a framework of action, different for each basic kind of product, which we label a world of production." (Storper 1997, p. 112).

interactions between (local) actors are intrinsically unique and thus hard to measure and compare across different systems. A potential solution to this problem is the "evolutionary integrated view of the regional systems of innovation" (Iammarino 2005). By comparing national (macro-level) and regional systems of innovation (micro-level i.e., that of firms and localised institutional networks), a meso-level emerges characterised by "local structural regularities from past knowledge accumulation and learning" (Iammarino 2005, p. 503). This implies the existence of a series of "external conditions in which externalised learning and innovation occur" (Cooke 1997, p. 485) which can be identified across innovation systems and on which innovation strategies can be based. These conditions act as "conditions that render some courses of action easier than others" (Morgan 2004) or "social filters" or, in other words, the unique combination "of innovative and conservative components, that is, elements that favour or deter the development of successful regional innovation systems" (Rodríguez-Pose 1999, p. 82) in every space.

2.5 R&D, Innovation Systems and Knowledge Spillovers

Territories can rely not just on their internal capacity to produce innovation either through direct inputs in the research process or through the creation of innovation prone systems in the local environment, but also on their capacity to attract and assimilate innovation produced elsewhere. Within the framework outlined in the previous sections innovation is not the result of a linear process. On the contrary, it has been shown to be the result of a complex set of interactions between innovative units (R&D departments within firms, universities, research centres etc.) and their external environment through the "network" structure of the regional economy.

Such interactions produce the transmission of knowledge in the form of "knowledge spillovers" (Jaffe 1986; Acs, Audretsch and Feldman 1992) that are reaped by local actors. The origin of knowledge spillovers can be local, but they can also be generated outside the borders of the locality or region object of the analysis, as "there is no reason that knowledge should stop spilling over just because of borders, such as a city limit, state line or national boundary" (Audretsch and Feldman 2003, p. 6). If there are internal and external sources of spillovers important questions arise. The first relate to the balance between internally generated innovation and externally transmitted knowledge and the extent to which a territory can rely on externally-generated knowledge for innovation. The second group of questions concern the local and external conditions that will maximise the diffusion of knowledge. While the final group deals with the capacity of knowledge spillovers to travel and the potential for distance decay effects. In order to address these questions we have to resort to the theoretical distinction between different communication technology of codifiable information and tacit knowledge. "Codifiable information is cheap to transfer because its underlying symbol systems can be widely disseminated through information infrastructure" (Leamer and Storper 2001, p. 650). However, information is not completely codifiable due to some specific features which, in some cases, make codification impossible or too expensive. "If the information is not codifiable, merely acquiring the symbol system or having the physical infrastructure is not enough for the successful transmission of a message" (Storper and Venables 2004, p. 354). In this latter case we can include "face-to-face" contacts that act as communication technology. Face-to-face contacts exhibit at least two relevant features for the processes under analysis: they are an intrinsically "spatial" communication technology and they are "socially" shaped. The space-sensitivity of such contacts is the mechanism through which geography and distance exert their influence over the process of innovation. The combination of physical geography, communication and transport infrastructures and urbanisation patterns determines how easy (difficult) and dense (sparse) such contacts will be, thus emphasizing (hampering) their "potential" as communication technology. However, while face-to-face contacts as a communication technology make the transmission of innovation possible they also pursue other functions that make communication more effective. Among these functions Storper and Venables (2004) cite the following: trust and incentives in relationships, screening and socialising and motivation. These functions are clearly influenced by the socio-institutional environment in which they take place. As a consequence not only is the "production" of innovation itself shaped by the "social filter" in place in the local economy but this latter factor also influences the extent and the effectiveness of the diffusion of innovation and knowledge. For this reason the role of interconnection between territories and the corresponding knowledge flows cannot be fully understood unless associated with the underling socio-economic conditions.

It is also reasonable to expect that face-to-face contacts are maximised within the region due to the effect of closer proximity and common socio-institutional infrastructure and networks. However, part of the "uncodifiable" knowledge produced in a region, could overcome the limits of the "institutionally defined" region thus "flowing" into neighbouring interconnected territories. However, and in contrast with codifiable information, the process of transmission of tacit knowledge is costly and would suffer from strong distance decay effects. Face-to-face contacts are maximised within relatively small territories, due to a combination of proximity and the presence of common socio-institutional infrastructure and networks. The potential to reap knowledge spillovers will thus be maximised within the region. Some of this knowledge will nevertheless spill over beyond the borders of the region or locality flowing into neighbouring areas, as a consequence of the existence of different forms of inter-regional contacts. Flows of interregional knowledge are thus important as agents of innovation, but their influence is likely to wane with distance (Anselin et al. 1997; Adams and Jaffe 2002; Adams 2002), as the potential for face to face and other forms of interaction decay.

Hence not only the local innovative efforts have an influence on the innovative output and on economic performance, but also on the capability to access external sources of "uncodified" knowledge. Such "accessibility to extra-regional innovation" in its turn must be confronted with the internal social-filter conditions which make communication more effective and determine to what extent such knowledge is translated into economic growth. The evidence of the spatial boundedness of knowledge spillovers not only contradicts the idea of ubiquitous knowledge evenly available everywhere, but also helps explain how peripherality can persistently hamper regional innovative capacity after controlling for indigenous innovative efforts: the smaller the spatial extent of knowledge spillovers, the lower the exposition of peripheral areas to externally produced knowledge. While highly-accessible core regions can benefit from innovative activities pursued in their proximity, the spatial boundedness of spillovers prevents them from reaching peripheral remote regions. As a consequence, the stronger the spatial decay of the spillovers the more accentuated their tendency to develop localised pools of knowledge in central locations.

2.6 The Diffusion of Knowledge Spillovers: How Institutional Factors and Global Networks Shape the Spatiality of Knowledge Flows

As O'Brien (1992), Cairncross (1997), and Friedman (2005) posit, there is little doubt that, in theory, progress in telecommunications and in the capacity to store and diffuse massive amounts of information online has greatly reduced the role of physical proximity for the development of economic activity. However, physical or geographical proximity (the focus of previous paragraphs) is only one dimension of proximity. Boschma (2005, p. 62) identifies four other dimensions: cognitive, organizational, social, and institutional. Cognitive proximity is related to the fact that "knowledge and innovations are often cumulative and localised outcomes of search processes within firms with a high degree of tacit knowledge" (Boschma 2005, p. 63). Organizational proximity refers to the organizational practices and interdependencies that facilitate interactive learning, while social proximity highlights the fact that economic activity is embedded in a social context (Granovetter 1985; Grabher 1993). Finally, institutional proximity refers to the presence of similar institutions, such as "a common language, shared habits, a law system securing ownership and intellectual property rights, etc" (Boschma 2005, p. 68) that provide the support for economic co-ordination. While Boschma (2005) is careful to state that these different types of proximity do not necessarily relate to geographical proximity, we will argue that the reason behind the emergence of core-periphery patterns is precisely the strong interdependence of all the different types of proximity and how these different proximities coalesce in large metropolitan areas and clusters (and hence in relatively reduced geographical scales from a world perspective).

Our tenet is that large urban agglomerations (high density of face-to-face contacts) in "central locations" (i.e., where exposure to external knowledge flows is maximised thanks to high accessibility) provide the setting where economic and social actors benefit from proximity to other economic and social actors with whom they can relate from a cognitive, organizational, social, and institutional dimension, creating the adequate environment for exchanges of ideas, Jacobs' type externalities, innovation, and ultimately, economic activity and growth (Duranton and Puga 2001). Large (urban and industrial) agglomerations provide the anchor for the flows generated by the information and knowledge society to take hold: it is true that advanced economic activity can now happen in more areas of the world than before, but, even in these places, it will tend to increasingly concentrate in a series of agglomerated relational nodes. In other words, physical proximity acts as an enabling force that makes other proximities more likely to be developed: physical proximity (at least on a temporary basis) is a necessary (though not sufficient) condition for the exchange of existing knowledge and the generation of innovative ideas. In this perspective, the innovative performance of countries and regions is not only the result of their innovative efforts but it is also influenced by the spatial configuration of their innovative agents. Such a spatial configuration not only influences the exposure to internal and external knowledge flows but also impacts upon the development of other crucial proximities by interacting with indigenous socio-institutional conditions.

The set of proximities needed to generate a virtuous circle of innovation – by allowing the emergence of complex innovative network relationships, operating between and across different scales (from local to transnational) – further contributes to the emergence of core-periphery patterns in the world economic geography. From this perspective "innovation systems are a combination of intra-local, extra local and transnational network connections" which "are not just intra or inter-corporate in nature (as highlighted in Faulconbridge 2006), but may also encompass other forms of social networks" (Coe and Bunnell, 2003: 454). These networks generate a multifaceted geography of relations in the world economy which may systematically favour some actors (those enjoying the best balance of the various proximities with the most innovative actors), while further marginalising those at the geographical, cognitive, organisational, social, and/or institutional periphery.

2.7 The Success of the "Core": Where Proximities, Relational Networks and Institutions Generate Local "Buzz"

The mechanisms discussed above provide us with a clear framework for the understanding of the economic success of leading cities and industrial agglomerations. The synergic co-existence of cognitive, organizational, social, and institutional proximities brought together in a reduced geographical environment and framed into a favourable socio-institutional environment gives rise to local "buzz". As discussed before, the concentration of local innovative activities improves local economic performance of "core" areas but also produce localised knowledge spillovers whose beneficial effects not only depend on proximity relationships, but also on the presence of local institutions (or social filters) enabling their absorption and translation into further economic growth. In addition, by enabling face-to-face contacts and the transmission of uncodified/tacit (or uncodifiable) knowledge – often in conjunction with their role of major nodes of (material and immaterial) global network relations – "buzz" areas in the economic "core" benefit from an enduring competitive advantage over other territories which reinforces other agglomeration forces in a process of cumulative causation.

The success of "buzz" areas also depends on other localised factors such as a favourable balance between specialisation and diversification. While increasing specialisation is likely to foster MAR (Marshall-Arrow-Romer) externalities within the same industry, the diversity of economic activities pursued locally allows local actors to benefit from knowledge base complementarities and across-industry exchange of ideas (Jacobian externalities). The empirical literature suggests that both MAR (Glaeser et al. 1992; Henderson 1999) and Jacobian externalities (Andersson et al. 2005; Carlino et al. 2001; Feldman and Audretsch 1999) may play an important role in fostering innovation either in different industrial contexts[4] or at different phases of a product life cycle.[5] A crucial issue for the prosperity and success of cities stems from the capability to efficiently exploit MAR and Jacobian externalities. When other forces (historical, institutional, political) prevent the evolution of the cluster from reaching its most efficient equilibrium at any moment in time between both types of external economies, overall economic performance could be hampered. Diversified cities tend to be larger while specialised cities are generally smaller in size. Whereas both diversified and specialised cities can in principle perform equally well, the potential risks for specialised cities are greater. These risks are related to their lower innovative capacity and their greater exposure to rise and fall patterns of specific sectors of specialised cities (Duranton and Puga 2000). In the long-run, intervention in the form of policies that encourage labour mobility (mainly to larger diversified cities) in order to address the decline of specialised cities may be needed. Hence it is fundamentally the unique mix of social, institutional, cognitive, and organizational proximities found in large metropolitan areas that once again allows for the adequate linkages to be developed and for the right mix of specialisation versus diversification to emerge.

Once this process is activated it has an enormous cumulative potential: the productivity of local innovative activities is significantly enhanced when the conditions mentioned above are met, generating the economic incentive for further investment. New investments in innovation, in their turn, not only produce localised spillovers but also directly and indirectly increase local absorptive capabilities and stimulate the continuous updating of the local socio-institutional environment. A favourable socio-institutional environment is, in its turn, prone to the development of outward connections, extra-regional interdependencies, and global network relations.

The most important buzz cities (e.g., London, New York, L.A.) are nodes of international business, financial and cultural networks, locations of the headquarters of many multinational corporations; they are at the very centre of "global" travel-and-meeting activities. However, "the highest levels of international business require

[4]Henderson et al. (1995) find that Jacobs-type externalities prevail in high tech and MAR in capital goods industries.

[5]Duranton and Puga (2001) suggest that firms develop new products in diversified creative urban contexts, subsequently, relocating to specialised cities in the mass production phase in order to exploit cost advantage.

insertion into locally-grounded government and political networks in order to function efficiently" and although "the precise mix of activities involving face-to-face contacts and collocation will change, they (...) will continue to generate agglomeration of highly skilled individuals, firms and bureaucracy in high-cost urban centres" (Storper and Venables 2004, pp. 366 and 368). This is reflected in Bathelt et al.'s (2004) "local buzz, global pipeline" model, which explicitly brings extra-regional dynamics to light: extra-agglomeration knowledge flows complement local buzz by means of investments in channels of communication (pipelines). If learning is "increasingly inserted into various forms of networks and innovation systems (at regional, national and international levels)" (Asheim and Coen, 2006, p. 171), cities are likely to become the centres of the knowledge based economy thanks to their capacity to act both as buzz environments and major nodes of immaterial/a-spatial/temporary networks. This process is not only about a few major world centres, but has produced a complex roster of cities where "buzz" cities are functionally interconnected by an uneven world city system (Beaverstock, Taylor, and Smith, 1999). Furthermore, the increasing importance of cities is likely to be complemented by the emergence and reinforcement of a number of highly specialised high-tech centres of excellence where the importance of global interconnections may complement and even exceed that of local buzz (Moodysson et al. 2005).

This set of economic forces is continuously shaping and re-shaping the world economic geography. However, the whole system is highly dynamic and big radical shifts in the technological frontier may allow new windows of opportunity to be opened (and others to be closed) thus allowing new cities and agglomerations to emerge in the global landscape but, at the same time, condemning other areas to economic decline.

2.8 Explaining Core and Periphery Patterns: The Foundations of an Integrated Empirical Framework

So far we have analysed how different theoretical approaches shed light upon a variety of mechanisms that link the process of innovation to regional economic performance. The analysis of these mechanisms has uncovered the complexity of the role of innovation in the genesis of regional growth and has made explicit the insufficient explanatory power of the linear neo-classical view of this process. However, in this same perspective, also the growth theories which attempted to incorporate the Schumpeterian legacy (Fagerberg 1988) – while providing a more realistic view of the process of innovation – still fail to account for the dynamics that emerge when the spatial/territorial dimension of the process is dealt with. The analysis of the complex factors shaping the relationship between innovative efforts and economic performance at the territorial level calls for an appropriate analytical framework. Such a framework should possess a number of important features that would make it a suitable foundation for empirical analysis and policy guidance: not only a tool for the detection of the factors of success in leading regions (e.g., as in the local buzz theory or in the "global pipelines" perspective) but a full-embracing conceptualisation of the determinants of regional growth in both core and peripheral areas.

Let us briefly discuss the key features of such a framework. In a first instance the empirical framework will take the linear relationship between local innovative efforts and economic growth as a point of departure. This will on the one hand provide us with solid foundations for quantitative analysis – linking directly our model with the endogenous growth perspective (Romer 1990; Cheshire and Magrini 2000) and the Knowledge Production Function approach (Griliches 1986; Audretsch and Feldman 1996; Audretsch 2003) – and, on the other, will ensure comparability with other existing studies on regional growth and convergence. In addition, by adopting the relationship between innovative efforts and the generation of new ideas/knowledge as its milestone, our conceptual framework will be a suitable foundation for both quantitative (as in the "mainstream" economics literature) and qualitative (as in large part of the literature on technological development and systems of innovation) analysis. The linear relationship between R&D, innovation and economic growth (typical of existing quantitative analyses) will progressively be developed in order to incorporate proxies for the relevant more "qualitative" conditioning factors singled out by other streams of literature (those on the role of institutions, geographical factors and distance in relation to the process of innovation).

In this perspective the model will combine insights from different streams of literature in an eclectic fashion. This book, throughout its chapters, will progressively develop the basic linear relationship between innovative input and economic performance and incorporate the complexity introduced by other streams of literature taking into account the role of space and socio-institutional conditions in a progressively more sophisticated way.

While cross-fertilising linear and non-linear, quantitative and qualitative approaches to the generation of regional economic dynamism, this conceptual framework will also reconcile the often contradictory views resulting from the adoption of either a top–down or a bottom–up perspective. The relative importance of the various determinants of regional growth varies significantly where assessed from opposed perspectives. Top-down analyses are designed to capture macro-developmental dynamics: as an example they can assess the aggregate average impact of innovative efforts on the economic performance of a cross-section of regions, highlighting common and "general" trends. In so doing these models will treat as a "residual" all specific idiosyncratic factors that differentiate one region from the other. Conversely, bottom-up analyses will focus their attention on the specificities of a set of regions capturing their unique internal dynamics but overlooking inter-regional trade offs and general trends. While these limitations are logical consequences of the perspective adopted, they significantly hamper the capability of these models to provide an accurate picture of the real world and act as foundations for development policies. In order to address this weakness of the existing literature, the empirical framework developed in this book aims to bridge top-down and bottom-up views on the process of regional and local economic development by adopting a meso-level perspective based on the inclusion into a macro-quantitative framework of proxies for factors generally treated as idiosyncratic (and confined into the residual) by mainstream analysis. By explicitly looking at quantitative variables grounded into a largely qualitative literature (e.g., systems of innovation) we will be able to test their generality as drivers for innovation and growth. Key qualitative concepts – traditionally addressed by means of case studies analyses – will be developed in order to be treated in a quantitative framework: this will imply further theoretical elaboration of the key concepts in order to emphasize their "non-strictly-idiosyncratic" component and indentify the most appropriate proxies. As an example let us consider how regional economic performance is profoundly influenced by extra-regional trans-local factors that have to do with the different ways in which regions interact with each other across distance. External, extra-regional factors impact upon local innovative performance by means of spillovers and externalities that can only be captured in a macro perspective by covering simultaneously a plurality of regions by means of the appropriate spatial weights (rather than by focusing upon one single regional case in isolation). However, the impact of such flows crucially depends on a set of localised (largely idiosyncratic but still partially generalizable) socio-institutional conditions that the meso-level integrated approach outlined above can effectively capture, providing us with a more realistic view on the functioning of the regional economy.

The realism provided by an eclectic integrated approach comes, however, at the price of a lower degree of internal coherence when compared to quantitative empirical models directly derived from macro-regional theories. But it will also mean that the following chapters of this book will show the empirical relevance of more qualitative factors brought into the picture by an integrated approach. In addition, the final conclusive chapter will show how this approach can serve as a needed meso-level foundation for local and regional development policies.

Following this line of reasoning, in this section, we show how the various theoretical perspectives discussed so far, can be brought together in a joint framework able to drive the specification of the empirical models presented in the following chapters. In other words we will attempt to mould different theoretical perspectives into an eclectic approach to the territorial genesis of innovation. In so doing we aim at singling out the "forces at work" in regional growth dynamics rather than testing the explanatory power of one theory of innovation against the other.

We assume Fagerberg's (1998) approach as the starting point of our analysis. This approach explicitly aims at overcoming the limitation of previous research on the explanations for differential cross-country growth rates: the "catch-up" analysis, the "growth accounting" and the "production-function" studies. The "catch-up" literature (e.g., Abramovitz 1986) seems unable to explain the forces behind the opening up of the observed technological gaps which, once established, become the engine for the diffusion of innovation through imitation mechanisms. The mainly descriptive contributions in this stream of literature have placed too much emphasis on diffusion processes while neglecting the importance of innovation for developments in leading countries and the persistent disadvantage of non-converging countries. The "growth accounting approach", for its part, fails to distinguish between "active" and "passive" factors of growth i.e., between the true determinants and supportive processes as well as failing to include innovation among such determinants. Finally, the production function approach, relying upon equilibrium assumptions, is not only methodologically inconsistent with the introduction of "disequilibrium" factors (i.e., unemployment) but necessarily fails to account for "differences in technological levels and innovative performance across countries, which we believe to be one of the most fundamental disequilibrium mechanisms in the world economy" (Fagerberg 1988, p. 438). Building on the limitations of previous contributions and assuming disequilibrium conditions "right from the start", Fagerberg (1988) proposes a "technology-gap theory" of economic growth as an application of Schumpeter's dynamic theory of capitalist development which explicitly assumes the interaction of two "conflicting" forces [innovation (which generates the technology gap) and imitation or diffusion (which tend to reduce it)] as an "engine of growth". The capacity to single out these two fundamental forces behind the process of economic growth makes Fagerberg's model particularly interesting for our approach.

The production function takes the form:

$$Q = ZD^{\alpha}N^{\beta}C^{\tau} \tag{2.1}$$

where Q is level of production of a country, Z is a constant, D is the level of knowledge transferred from abroad, N the level of knowledge created in the country or "national technological activity", C is the country's capacity for exploiting the benefits of knowledge (both from D and N).

Following Fagerberg, by differentiating and dividing through with Q, denoting growth rates with small-case letters, we obtain:

$$q = \alpha d + \beta n + \tau c \tag{2.2}$$

As a further step Fagerberg (1988) assumes, "as customary in the diffusion literature, (...) that the contribution of the diffusion of internationally available knowledge to economic growth (*d*) is an increasing function of the distance (T/T_f) between the level of knowledge appropriated in the country (T) and that of the country on the technological frontier (T_f)" (p. 439). Thus substituting the resulting equation for d in (2.2), we obtain the final specification of Fagerberg's model:

$$q = \alpha(T/T_f) + \beta n + \tau c \tag{2.3}$$

Equation (2.3) is the point of departure for the specification of our empirical model which only partially follows Fagerberg's (and Fagerberg et al. 1997 for an application to European regions) specification. The main point of contact between our model and those of the technology gap literature – and that of Fagerberg et al. (1997), in particular – is the assumption of GDP per capita as a proxy for the potential for imitation (T/T_f). As the total level of knowledge appropriated in the country (T), i.e., the total set of techniques in use, cannot be measured directly, a measure for the output of the process embedding such techniques has to be considered. This measure is the level of productivity (Q/L), usually proxied by

GDP per capita. Thus we suppose that the lower the productivity (GDP per capita) of a region the farther the technological frontier and, consequently, the higher the potential for imitation. However, as pointed out by Fagergerg in first instance, the process by which a country could fill such gap is not automatic (as assumed, through different mechanisms, by equilibrium-based models), but depends upon national innovative performance (n). This emphasis on innovative efforts is the main point of contact between the "technology-gap" approach *à la* Fagerberg and some (later) contributions in the "endogenous growth" literature which have more explicitly assumed the Schumpeterian idea of innovation as an endogenous factor explaining productivity growth in the economy (Romer 1990; Grossman and Helpman 1991; Aghion and Howitt 1992).

As a consequence the idea that "the scope for imitation combined with investment or education or both works well to explain differences in growth across countries" (Fagerberg, Verspagen, von Tünzelmann 1994, p. 10) fairly represents the change in the perspective of the "formal analytical" literature that in different ways attempted at incorporating the Schumpeterian legacy ("technology gap" and "endogenous growth") from the traditional Cobb-Douglas production function approach (Fig. 2.1). This same idea is incorporated in our empirical model which, as discussed above, aims at overcoming its limitations by including into the analysis the processes singled out by the "systems of innovation approach", on the one hand, and by the literature on localised knowledge spillovers and the spatial dimension of the process of innovation, on the other.

Consequently, the proposed model is substantially different from that of Fagerberg, as we do not consider capital investment as "an indicator of growth in

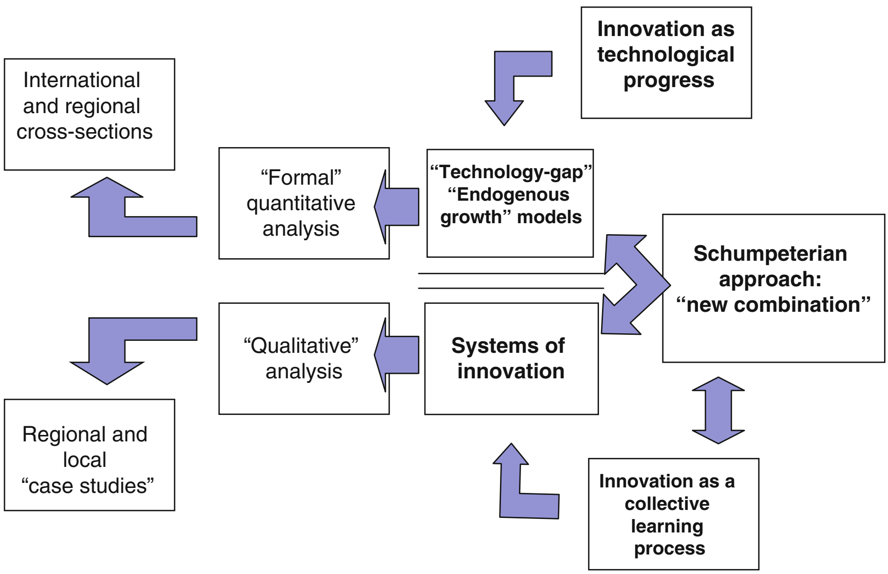

Fig. 2.1 Conceptual map of existing literature on innovation and growth
Source: Authors' elaboration

the capacity for economic exploitation of innovation and diffusion" (Fagerberg 1988, p. 447) as capital investment should be seen as an effect rather than a cause of growth (as later acknowledged in Fagerberg et al. 1997). As an alternative, we introduce human capital accumulation as a better proxy for the diffusive mechanism of innovation. We also propose a simple model which tries to combine the key factors from the three strands of literature presented in the previous sections (Fig. 2.2): endogenous innovative efforts, socially and territorially embedded factors, and spatially-bound knowledge spillovers. The model is aimed at understanding – and, to a certain extent, discriminating among – the role of the different innovation factors proposed by different strands in order to generate economic dynamism.

The systems of innovation approach provides fundamental insights into such dynamics, but the lack of "theoretical borders" for this approach[6] means that it is not a theory of innovation but a "focusing device" for factors relevant for the process of innovation (Edquist 1997). The concept, similarly to that of the "innovative milieu", should thus be interpreted not as a full explanatory model but rather as a "meta-model" able to show the relevance of some specific factors for a broader phenomenon[7] (Camagni 1995).

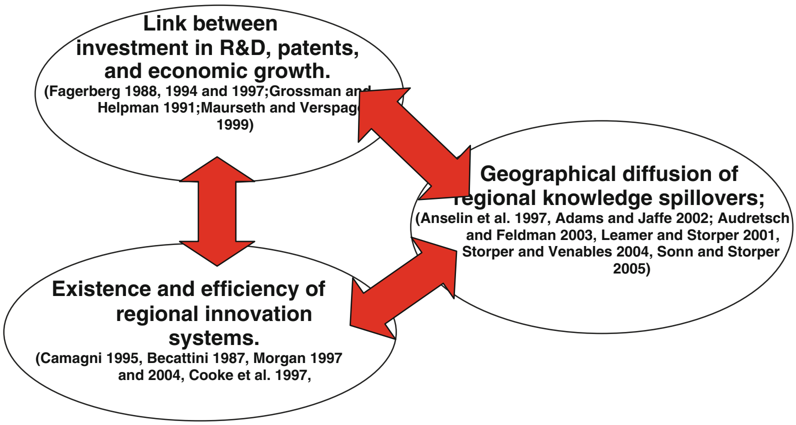

Fig. 2.2 Streams of literature combined in the model of empirical analysis
Source: Author's elaboration

[6]"… at the present state of the art, defining the limits of a system of innovation in this way (as all determinants) is a "catch 22" problem. (…) We will, for the time being, specify systems as including all important determinants of innovation. (…) In this way the approaches serve as 'focusing devices' (…): interesting conjectures that need to be specified and then verified or disproved through further research."(Edquist 1997, p. 15).

[7]Cantwell and Iammarino (2003) make this specificity explicit when stating that "proper regional systems of innovation are found only in a few well-defined areas: in most regions systemic interactions and knowledge flows between relevant actors are simply too sparse and too weak to reveal the presence of systems of innovation at work" (p. 5).

However, these specificities of the innovation systems approach do not prevent us from including the "lesson" of such a model in a broader theoretical framework able to deal with more general empirical analysis (Fig. 2.1).

The innovation systems approach has challenged the linear relationship between innovative efforts, productivity and growth, developed in the endogenous growth framework, stimulating and enriching the theoretical perspective on innovation. However the inclusion of this broader set of explanatory factors in the explanation of growth performance, as we underlined above, is not new in the field of quantitative analysis in economic geography and regional development (e.g., Rodríguez-Pose 1994, 1998a and 1998b; Cheshire and Carbonaro 1996, Cheshire and Magrini 2002). Building on such contributions we support the idea that the variety of factors brought into "focus" by the innovation systems approach, while resistant to any generalisation when used as linear predictors for innovative performance, may instead play a (statistically significant) role as "supportive" variable whose explanatory power lies in their interaction with innovative efforts.

The same line of reasoning applies to the literature on the spatial diffusion of knowledge flows. In many cases this literature has remained either theoretical (Storper and Venables 2004), disconnected from regional growth analysis (Sonn and Storper 2005) and/or limited to case studies (literature on local "buzz"). Even where in-depth analyses have been implemented in order to capture the empirical relevance of spatially-mediated knowledge flows (Adams and Jaffe 2002), their interaction with the underlying absorptive conditions has remained unexplored. The lack of a common theoretical perspective and the different languages of separated streams of literature have hampered the possibility to look at spatial knowledge flows jointly with the factors conditioning their impact on the regional economy. Our empirical framework, by building upon the commonalities of these different streams of literature and incorporating them into a formal innovation-led regional growth model, will allow us to directly capture the role of innovation systems as potential catalyser for the absorption of localised knowledge flows and their translation into economic activity.

The operational translation of all these concepts and further theoretical justification for their introduction into our growth model will be discussed in greater detail in the chapters specifically devoted to the analysis of the insights offered by each of these factors for the analysis of regional growth and innovation dynamics.

In general terms (2.3) is extended by combining, as discussed above, proxies for the regional system of innovation [c in (2.4)] and for the spatial dimension of the process of innovation [the variable (g) in (2.4)]:

$$q = \alpha(T/T_f) + \beta n + \tau c + \gamma g \tag{2.4}$$

The basic model to be estimated in following chapters is:

$$\frac{1}{J}\ln\left(\frac{Y_{i,t}}{Y_{i,t-J}}\right) = \alpha + \beta_1 \ln(y_{i,t-J}) + \beta_2 innovation_{it} + \beta_3 innovation\_systems_{it} + \beta_4 geography_{it} + \beta_5 D + \varepsilon \tag{2.5}$$

where:

$\frac{1}{J}\ln\left(\frac{Y_{i,t}}{Y_{i,t-J}}\right)$	Is the usual logarithmic transformation of the ratio of regional per capita GDP at the two extremes of the period of analysis (t−J,t);
α	Is a constant;
$\ln(y_{i,t-J})$	Is the log of the GDP per capita at the beginning of the period of analysis (t−J)
Innovation	Is a measure for innovative efforts;
Innovation system	Is a proxy for the local system of innovation including the level of human capital accumulation;
Geography	Is a proxy for the effect of space and geographical distance (e.g., aggregate measure of accessibility, innovative efforts and socio-economic conditions in neighbouring regions);
D	Is a set of national dummies;
ε	Is the error term.

The various specifications of this model presented in the following chapters combine inputs in the innovation process (R&D expenditure) with the socio-economic local factors that make the presence of favourable regional systems of innovation more likely, while controlling for the wealth of European regions. These factors are considered locally, i.e., the R&D and the local conditions in the region under study, and externally, i.e., the conditions in neighbouring regions in order to assess the importance of the geography of these factors in the form of spillovers. Finally we control for the influence of national factors, such as the presence of national systems of innovations. However, the need for a feasible specification of the innovative process, which inevitably implies some simplistic assumptions, must not hide the complexity of the real world as represented by the systems approach. We should thus resist the temptation of a "linear interpretation"[8] of the results of our empirical analysis, but rather take full account of the complexity of the underlying mechanisms behind the results.

The models of empirical investigation employed in the following chapters of this book are based on different specifications of this general base model. In particular, in Chap. 3 the role of peripherality in explaining differential capabilities to translate innovation into economic growth will be assessed by means of an aggregate index of accessibility. In Chaps. 4 and 5 the analysis will be broadened by including a more in-depth quantitative analysis of regional systems of innovation and of the spatial extent of knowledge flows respectively. In Chap. 6 this approach will be further expanded by accounting for specialisation and agglomeration patterns and applied to the comparative analysis of the innovation dynamics in Europe and the United States and, finally, in Chap. 7 to the analysis of the impact of the transport infrastructure policy of the EU on regional growth performance.

[8] "(. . .) the mere introduction of sets of social and political variables into linear models of growth does not by itself solve the problem of what type of relationship there is between the socio-political setting and economic growth" (Rodríguez-Pose 1998, p. 46).

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